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ORIGINAL RESEARCH

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Bulk-flow composites in paediatric dentistry: long term survival of posterior restorations. A retrospective study

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Abstract

Dental decay is a prevalent bacterial disease affecting a significant percentage of children globally. In paediatric dentistry, various materials are available for restoring deciduous teeth, addressing both functional and aesthetic concerns. However, paediatric dentists encounter challenges related to patient compliance, limited working time, and material handling. This study aims to observe the survival rate of bulk-fill composite restorations in paediatric patients over a five-year follow-up. A total of 198 patients aged 0 to 12 years underwent 673 class II restorations on deciduous first molars (1M) and second molars (2M). All restorations were conducted performed by 1 Pediatric DDS resident students from the Paediatric Dentistry Department (Padova University), utilizing using different isolation techniques. Bulk-fill composite restorations were evaluated over a five-year follow-up, and data were collected by a single investigator. After five years, 177 patients and 611 restorations were assessed. The retention rate was higher in primary second molars than in first molars, with fewer marginal dyschromies and less formation of secondary caries. The overall failure rate was higher in primary first molars and primary lower second molars. Bulk-fill composites demonstrated significantly positive performance in terms of retention, maintenance, and marginal dyschromies. Bulk-fill composites are promising materials of choice in paediatric dentistry due to their easy handling and favorable properties. Further research is necessary to compare high and low viscosity bulk-fill composites and assess the impact of different variables on restoration success.

Keywords

Dental decay; Paediatric dentistry; BFC; Restoration techniques

1. Introduction

Dental decay is a widespread multifactorial bacterial disease affecting approximately 19% to 89% of children globally [1]. Deciduous dentition is particularly susceptible to carious lesions, and if left untreated, caries can progress, leading to disruptive pain and discomfort. Various materials have been developed in pediatric dentistry to restore deciduous teeth, ensuring not only proper function, but also pleasing esthetics.

Pediatric dentists often face challenges related to patient compliance, limited working time, and material handling. Therefore, selecting the most suitable material becomes crucial for successfully completing treatment, especially under "less than ideal" conditions [2].

In the selection of dental materials, a pivotal consideration is the patient's adherence to the treatment. With a cooperative patient, the rubber dam can be effectively placed, and composites can be appropriately stratified. However, these materials are not recommended in scenarios of low compliance, such as with toddlers, anxious patients, or those who have undergone previously traumatic treatments [3].

For such patients, it is preferable to opt for the Atraumatic Restorative Treatment (ART) technique, where the decayed portion of the tooth is carefully removed using a manual excavator [4].

Typically, in such cases, preference is given to glass-ionomer composites (GICs) or resin-modified glass-ionomer composites (RM-GICs). This choice is attributed to the need for a shorter working time. The material can be applied in a single step, and if necessary, it is easier to perform later interventions when better patient cooperation is achieved [5]. However, there is a higher rate of failure in restorations of deciduous teeth influenced by various factors such as the quality of isolation and adhesion, restoration structure and surface, patient compliance, and the quality of the dentine and enamel beneath the filling [6].

Advancements in monomer technology have led to the emergence of a novel composite type known as bulk-fill composites (BFCs). These composites can be viewed as an "evolution" from traditional counterparts, specifically designed for extensive cavities where the application of conventional composites would demand an extended treatment duration in the dental

chair. The reduced contraction following polymerization enables their application in depths of approximately 4–5 mm [7].

Bulk-fill composites (BFCs) exhibit less shrinkage, polymerization stress, cusp deflection, and micro-hardness in comparison to conventional composites. In addition, they demonstrate similar marginal quality, flexural strength, and fracture strength as their conventional counterparts [8]. Despite their high translucency and ease of refinement and polishing, they are not recommended for esthetic regions since conventional composites offer better esthetic outcomes. Unfortunately, BFCs currently have a limited range of shades, making them more suitable for posterior regions [9].

In the past, when only a few flowable composites were available, there was a higher incidence of marginal gaps between the tooth surface and the restoration. This was attributed to the high elastic modulus and plastic deformation during polymerization. However, with the introduction of BFCs in flow modality, the occurrence of such gaps has significantly decreased [10]. Diverse ranges of BFCs exist, each serving different purposes and possessing unique properties. Variations in the organic matrix, particles, fillers and molecular weight differentiate these materials. The most suitable BFC can be selected depending on the type of cavity to be filled [11].

In 2015, Hirata outlined two distinct restorative techniques suitable for bulk-fill composites (BFCs). One approach involves applying the BFC in a single step, covering the entire cavity surface and shaping it before polymerization. Alternatively, BFCs can be used as a flowable material to restore the dentin, with the final 1.3 mm covered using traditional composite to replicate the enamel surface in a technique referred to as the “sandwich technique” [12].

Due to the straightforward handling of these materials, BFCs are extensively employed in pediatric patients of varying age groups [13].

The objective of the present research is to comprehensively investigate the long-term performance of bulk-fill flow composite restorations over a period of five years, with a particular focus on the aspects of retention, maintenance and marginal dyschromia. The study aims to provide a thorough understanding of how these restorations withstand the test of time, shedding light on their durability, stability, and potential discoloration at the restoration margins.

2. Materials and methods

Between 2017 and 2018, 198 patients (88 males and 110 females), between 0 and 12 years of age were treated in the Pediatric Dentistry Department of Padova University in Italy. All restorations were performed by 1 Pediatric DDS resident from the Paediatric Dentistry Department (Padova University).

A total of 673 Class II Black restorations were examined with 387 restorations on deciduous first molars (1M) and 286 restorations on deciduous second molars (2M) (Fig. 1).

In order to minimize the relative error in the operative methodology, the evaluation of the restoration was performed by a single Pediatric DDS (L’Aquila University)

Depending on the collaboration, different isolation techniques were used: rubber dam with clamp, rubber dam with auto-matrix (Automatrix Kit, Densply Sirona, Italy) or cotton rolls. After the complete cleaning of the cavity (International Caries Detection Assesment, ICDAs, between 3 and 5) [14] with a diamond bur mounted on a highspeed handpiece, and a steel bur mounted on a blue-ring contra-angle, 37% orthophosphoric acid was applied for 15 seconds on the dentine and 30 seconds on the enamel, followed by washing for 40 seconds with water. A universal adhesive (Scotchbond Universal Adhesive, 3M ESPE, Sn. Paul, MN, USA) was properly applied with a brush, then polymerized for 40 seconds. A Bulk-fill flow composite (Filter Bulk-Fill Flow sir.2X2gr, A1, 3M ESPE, Sn. Paul, MN, USA) was used, applied in the one-step technique for a maximum of 4 mm and polymerized for 40 seconds.

All teeth that involved the pulp were excluded from the present study.

Patients were recalled for the annual controls (at least once a year), depending on their caries risk. A reinforcement of oral hygiene was imparted for all patients. After 5 years of follow-up, the restorations were finally evaluated.

Retention, maintenance and marginal dyschromia of the restorations were evaluated by eye and dental speculum. Secondary caries were evaluated by eye and radiograms (Table 1) [15].

3. Statistical analysis

A modified analysis using the United States Public Health Service criteria (USPHS) was first conducted by the same investigator and then repeated on 120 restorations by a second investigator to optimize the method error.

From the USPHS analysis, only retention, marginal dyschromia and secondary caries were taken into consideration.

4. Results

From the 198 patients (88 males and 110 females) and 637 restorations, twenty-one dropouts were registered with 11 patients having changed their dentists, 6 moved to a different city, 1 passed away and 3 patients were not available for the follow-up (Fig. 1).

Of the 611 restorations taken into account, 328 were done on 1M and 283 on 2M.

In the deciduous first molars, 192 restorations were retained; 47 restorations reported an acceptable marginal filtration and 31 were partially lost or with an unacceptable marginal filtration. In 122 restorations, no marginal dyschromia was reported; in 102 restorations a superficial marginal dyschromia was observed, and in 46 restorations, a deep marginal dyschromia was present. Two hundred and thirty-one restorations were free of secondary caries, while in 39 restorations, secondary caries was present.

In the deciduous second molars, 212 restorations were retained; 38 restorations had a marginal filtration and in 16 restorations, a partially lost or an unacceptable marginal filtration was reported. In 155 restorations, no marginal dyschromia was reported; there was a superficial marginal dyschromia in 100 restorations, and the margin was deeply dyschromic in 11 restorations.

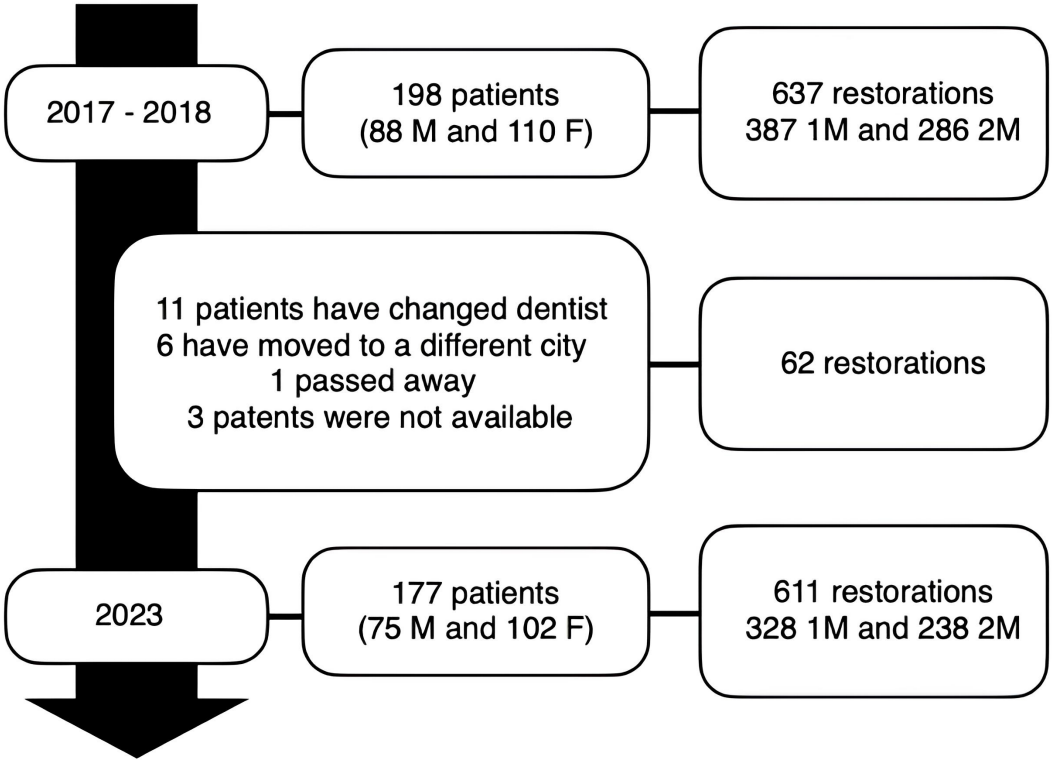

FIGURE 1. Timeline, patients, restorations and dropouts.

TABLE 1. United States Public Health Service criteria (USPHS).

Criteria	ALPHA	BRAVO	CHARLIE
Retention/Maintenance	Present	Clinically acceptable partial loss	Clinically unacceptable total or partial loss
Color	Correspondent to adjacent teeth	Clinically acceptable non-correspondent	Clinically unacceptable non-correspondent
Marginal Dyschromies	Non-marginal dyschromies	Superficial marginal dyschromy	Deep dyschromies reaching the pulp
Secondary Caries	Absent	N/A	Present
Shape Maintenance	Maintenance of the original anatomy	Changes in anatomy, but not requiring substitution	Changes in anatomy which require substitution
Marginal Adaptation	Continuous and entire margins	Mild discontinuous margins not requiring substitution	Discontinuous margins requiring substitution
Post-operative Sensitivity	Absent	N/A	Present

Two hundred and thirty-four restorations were free of secondary caries, while in 32 restorations, secondary caries was observed. For more details, please refer to Table 2.

5. Discussion

BFCs have been largely employed in pediatric dentistry since they were first available on the market around the end of the 1990's. According to our results, there is a higher incidence of restoration retention in primary second molars than in primary first molars (Table 3). A lower incidence of marginal dyschromia and secondary caries was reported in the primary second molars (Table 3).

A possible explanation could be the planned extraction or the premature tooth loss of those primary elements. In primary first molars, a lack of retention occurred due to the major difficulties in keeping the field properly isolated. In fact, it could be a tricky task to place the rubber dam on a pediatric patient, especially in cases where fear and anxiety are already present [16].

As mentioned above, if proper isolation is not obtained, there are concrete possibilities that the restoration may fail or experience a partial loss [17].

The shape and structure of the restoration were not assessed because primary teeth undergo natural tooth wear and abrasion, similar to their restorations. Typically, there are no discernible effects such as infiltration or microleakage, regardless of the adhesive procedure employed. In most cases, it would have

TABLE 2. Results of the observational study (5 years apart).

	First Molars	Second Molars	Changed teeth
Retention/Manteinece			
ALPHA	192	212	58 + 17
BRAVO	47	38	
CHARLIE	31	16	
Marginal Dyschromies			
ALPHA	122	155	58 + 17
BRAVO	102	100	
CHARLIE	46	11	
Secondary Caries			
ALPHA	231	234	58 + 17
CHARLIE	39	32	
Total	270	266	75

TABLE 3. Timing, number of observed patients, age, number of restorations analyzed and type of restored teeth at T0, year 2017–2018, and at T1, year 2023.

Timing	T0 (2017–2018)	T1 (2023)
N° of patients	198 patients 88 males 110 females	177 patients 75 males 102 females
Age	0–3 aa → 2M–1F 3–6 aa → 30M–39F 6–9 aa → 56M–70F	0–3 aa → 2M–1F 3–6 aa → 26M–34F 6–9 aa → 51M–63F
N° of restorations	673 restorations	611 restorations
Restored teeth	387 first deciduous molars 286 second deciduous molars	328 first deciduous molars 283 second deciduous molars

aa: age; F: female; M: male.

encountered a total lack of the anatomy [18].

In the present study, translucency and color were not considered, since in posterior teeth, esthetics is not as important as function, which instead must be primarily restored [9].

Regarding superficial and deep dyschromia, the necessity of a secondary restoration was considered depending on the radiological evaluation and the symptomatology of the patient. According to the literature, bitewing X-rays are considered the most dependable radiographs for evaluating the need for secondary restorations. Hence, bitewings were selected for this purpose [19].

In marginal dyschromia, the substitution of the previous restoration was performed only in those teeth where the contiguous permanent teeth were at Stages II and III of development, and no mobility were reported in the primary teeth.

However, post-operatory sensitivity is not reliable with pediatric patients, especially in those cases at Stage III resorption, and for this reason, sensitivity was excluded from the long-distance follow-up and more credit was given to the radiographic evaluation when dyschromia following marginal filtration was suspected [20].

On the 5-year follow-up, the total failure of the restoration (due to tooth loss or substitution) was 31 + 16 in the primary first molars (17.4%) and 16 + 11 in the primary second molars. It must be considered that some elements were extracted during the follow-up visit since there was physiological mobility (Table 3).

Similar results were found by Chisini *et al.* [21], 2018. In fact, according to that study, BFCs reported an annual failure risk (AFR) between 1.7% and 12.9%, representing the least value compared with other materials.

In 2021, Lea Hoffmann and colleagues studied the resistance to stress and AFR in low density and high density BFCs, stratified in 4 mm and 2 mm, respectively. They found that no statistically significant differences were reported in resistance to the stress and failure rates between low and high viscosity BFCs during a 2-year follow-up. Eight failures were also observed with 160 restorations during the entire study, which represents a 5% failure [22].

A clinical study published in 2022, by Yazici *et al.* [23], compared the performance of two different bulk-fill and nanofill composites in Class II restorations with a follow-up of 6 years. At the end of 6 years, a marginal discoloration was reported between 9.1% in the Tetric EvoCeram Bulk Fill group and 36.4% in the Filtek Ultimate group, and they were both rated as Bravo [23].

In another randomized prospective trial conducted by Hoshino *et al.* [24], in 2022, the study assessed flowable

bulk-fill resin composites in Class II restorations, comparing them with a conventional layering technique over a 4-year follow-up period. Fifty-three subjects received three Class II restorations each, utilizing different restorative systems: the first group used Amelogen Plus, the second group used Filtek Bulk Fill Flow, and the third group used SDR®. A total of 106 restorations were evaluated after 4 years. Both systems employing bulk-fill composites (second and third groups) exhibited higher marginal discoloration, but demonstrated better performance in terms of wear resistance and surface staining. The restorative systems utilizing flowable bulk-fill composite resins displayed satisfactory clinical performance compared to conventional composite resin after the 4-year period. However, all restorative systems showed a decrease in proximal contact after 4 years [24]. These results are comparable to the present findings since the retained restorations evaluated as Bravo were 37% in both the first and second molars and Charlie were rated 17% in the first molars and 4% in the second molars.

De Oliveira Correia *et al*. [25], 2023 investigated the clinical performance of bulk fill composites on cervical lesions after a 30-month follow-up in sixty permanent teeth in an adult population. After 30 months of clinical evaluation, 52 restorations showed marginal staining for the USPHS criteria ($p < 0.01$). A significant difference was found between 30 months *vs*. 1 week and 30 months *vs*. 6 months ($p < 0.01$) for all groups. No significant difference was found for the other parameters [25].

As a result, there was a notably elevated incidence of marginal staining, potentially attributed to the possibility that adults may engage in behaviors detrimental to their oral health, such as smoking or alcohol consumption, hence, marginal staining is evident. It is important to consider that in the present study, the lesions treated were cervical caries, whereas bulk-fill composites were intended for Class I and II restorations. Furthermore, according to De Oliveira Correia, after 30 months of clinical evaluation, 8 restorations were lost with a range between 78% to 98%, depending on the cervical extension of the restoration [25]. In a randomized clinical trial conducted by Sekundo *et al.* [26], in 2022, the study aimed to assess the clinical survival and quality parameters of Class-II restorations using a bulk-fill composite resin compared to a conventional nanohybrid composite resin in a split-mouth design. A total of 120 direct restorations were performed in the permanent teeth, with 60 restorations using Filtek Bulk Fill Posterior and 60 using Filtek Supreme XTE.

Seventeen restorations (14.2%) were lost in the follow-ups, resulting in 51 restorations available for survival analysis in the test group and 52 restorations in the control group. Among these, seven restorations experienced unfavorable events and were classified as failures. Four failures were observed in the bulk-fill restorations, attributed to tooth fracture (n = 1), chipping fractures (n = 2), and recurrent decay (n = 1). In the conventional nanohybrid composite group, three failures occurred due to adhesive failure (n = 1), tooth fracture (n = 1), and chipping with recurrent decay (n = 1). However, the difference between the test and control groups was not statistically significant ($p = 0.7$) [26].

Comparable results were noted in the present study, wherein an initial 387 restorations were carried out on first deciduous molars. After a 5-year follow-up, 328 of these restorations were assessed. Similarly, 286 restorations were executed on the second deciduous molars, with 283 of them undergoing analysis. In summary, 85% of first molar restorations and 98% of second molar restorations were maintained after the 5-year follow-up (Table 2). Regarding the occurrence of secondary caries, the present study found that only 39 first molars and 32 second molars were affected, accounting for 14% and 13% of the total evaluated restorations after 5 years, respectively (Table 3).

Based on these findings, it can be asserted that bulk-fill composites contribute to the adequate retention and maintenance of the restoration over time, especially in Class II restorations.

According to a recent systematic review with meta-analysis by Arbildo-Vega *et al.* [27], the clinical performance of traditional composites and BFC for carious lesion restorations is similar in terms of absence of fracture, discoloration, marginal staining, marginal adaptation, absence of secondary caries, color stability, translucency, integrity, water resistance and post-operators' sensitivity [27].

Various materials are currently accessible in the market, providing a broad selection for different applications. Currently, GICs are widely employed in pediatric conservative treatment due to their favorable properties. GICs release and absorb fluoride, and they are favored by pediatric dentists for their ease of handling. Nevertheless, for restorations intended for long-term durability, GICs are not recommended due to their documented fragility and vulnerability to wear and chipping, as highlighted in numerous studies comparing the performance of BFCs and GICs [28–30].

Regarding composites, they are appreciated for the physical and esthetic properties and they are more highly resistant to teeth wear, fracture and erosion than GICs. They have an optimal adhesion that allows a more conservative preparation and a minimally invasive approach. High density composites are more resistant to wear and mastication, while low density composites are more esthetically pleasing. They have high contraction to polymerization that can be easily overcome by accurately stratifying the materials. However, it might lead to longer treatment times, which is generally not convenient in the pediatric population. Furthermore, adequate isolation of the operator field is needed since composites do not tolerate humidity during manipulation, which make them not the first choice in cases where there is not enough compliance and rubber dams cannot be used [31–33].

6. Limitation of the study

The research focused exclusively on patients treated at the Pediatric Dentistry Department of the University of Padua between 2017 and 2018. The main limitation regards the patient's cooperation in oral hygiene maintenance and diet habits during the observation time caused by a lack compliance in regular visits.

7. Conclusions

Taking into account the myriad of options in the market, and considering the literature, BFCs emerge as a favorable solution for both dentists and pediatric patients, encompassing esthetic, manual and economic perspectives. BFC presents advantages in pediatric dentistry owing to their easy handling and adeguate properties, making them a preferred choice. The outcome of BFCs in pediatric dentistry can be influenced by various factors, including age, isolation techniques, adhesion methods, patient compliance, preparation techniques, dentist's skills, and the quality of the material used.

Further research is recommended in this area, including evaluating the prevalence of BFCs between the first and second molars in primary dentition and between high and low-viscosity BFC.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

PL and RG—designed the research study. PL and RG—performed the research. PL, SM and FSL—analyzed the data. RGP and FSL—wrote the manuscript. AG, FSL and ES—Visualization and Supervision. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethics approval was waived by local ethical committee of AOUP (Azienda Ospedaliera Università di Padova) as it is a retrospective study. All patients' parents signed the informed consent form in order to participate in the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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